PROJECT ZENO-ICE

Mathematical Appendix & Statistical Analysis Plan
Version v1.3 (Audit-Sealed)

Purpose

This document provides the complete equation derivation, estimators, and test procedures for Project Zeno-Ice. It is mechanism-neutral, falsifiable, and intended for academic archiving.

Indices and Time Grid

Let $N \geq 1$ be an integer such that there are $N+1 \geq 2$ timepoints. Measurements are indexed by $i = 0 \ldots N$ with $t_i = i \cdot \Delta t$ ($\Delta t > 0$ minutes).

Per-Sample Linear Model

For each sample: $m_i = \alpha + \beta\, t_i + \varepsilon_i$, where ε_i are i.i.d. with finite variance. No distributional assumption is imposed.

OLS Slope Estimator

$\beta\blacksquare = \Sigma(t_i - t\blacksquare)(m_i - m\blacksquare) / \Sigma(t_i - t\blacksquare)^2$. Define melt rate $k\blacksquare = -\beta\blacksquare$ (g/min).

Analytic Denominator

For uniform spacing $t_i = i\Delta t$, $\Sigma(t_i - t\blacksquare)^2 = (\Delta t)^2 \cdot N(N+1)(N+2)/12$. This avoids recomputation when Δt and N are fixed.

Group-Level Statistics

Group means $\mu\blacksquare_g$, variances s_g^2, and standard errors $SE(\mu\blacksquare_g)$ are computed on slope estimates.

Primary Hypothesis Tests

Primary inference uses two-sided permutation tests on slopes for Pattern vs Control and Pattern vs Sham, with Holm correction at $\alpha = 0.05$.

Decision Rule

Evidence for a pattern-associated effect is declared only if both contrasts are significant under Holm correction; otherwise the null result is accepted.

Effect Sizes

Raw mean differences and Hedges' g are reported, with bootstrap confidence intervals ($M \geq 5{,}000$ resamples).

Covariate Adjustment

If needed, mean temperature per sample is included as a sample-level covariate in slope-level regression.

Quality Control

Exclusion thresholds (e.g., missing data >20%, $R^2 < 0.70$) must be pre-declared prior to data collection.